Department of Mechanical Engineering
THE UNIVERSITY OF HONG KONG

SEMINAR

Tracing the Lifecycle of Charges in Organic Solar Cells: How Triplet Excitons Shape Recombination and Efficiency Limits

Date: 5 December, 2025 (Friday)
Time: 11:00 a.m. – 12:00 noon
Venue: Room 7-34, Haking Wong Building, HKU

Speaker: Professor Safa Shoaee
University of Potsdam and
Paul Drude Institute for Solid State Electronics
Germany

Abstract:

The power conversion efficiency of organic solar cells has recently surpassed 20%, yet a unified framework that captures the underlying photophysical mechanisms remains elusive. These devices operate through a complex excited-state choreography arising at the donor-acceptor interface where excitons, charge transfer (CT) and charge-separated states continuously interconvert according to the materials' energetic landscape.

In this talk, we share our kinetic model that, for the first time, explicitly incorporates the formation and re-splitting of local triplet excitons. Fully parameterised by the interfacial energy offset, this unified framework reproduces key photovoltaic observables – such as the charge generation efficiency, photoluminescence, electroluminescence and Langevin reduction factor. Our results show that the triplet state dynamics govern device performance across a wide range of energy offsets. In systems with short triplet lifetime, triplet decay emerges as the dominant recombination pathway, reconciling long-standing experimental findings, including those in benchmark systems like PM6:Y6. In systems with long triplet lifetimes, triplets can be recycled to mitigate this loss channel. The model further offers a mechanistic explanation for the empirically observed link between energy offset and reduced-Langevin recombination, and accurately predicts the device efficiency across different material systems.

Notably, it identifies asinglet-CT offset of ~150 meV as optimal for efficient charge separation while suppressing loss pathways. By connecting excited-state kinetics with macroscopic device metrics, our work provides a unified mechanistic picture of the photophysics in organic semiconductors.

Biography:

Safa Shoaee's research centres on organic semiconductors, with a particular emphasis on developing environmentally sustainable solar cells and energy devices.

She holds a dual appointment as a professor at the University of Potsdam and leading the Heterostructure Semiconductor Physics group at the Paul-Drude-Institut in Berlin.

Shoaee earned her PhD from Imperial College London in 2010. Following postdoctoral positions at both ICL and the University of Queensland, she was awarded the Sofja Kovalevskaja Prize to establish a research group at the University of Potsdam. Her expertise and leadership were further recognised in 2018, when she was appointed associate professor.

ALL INTERESTED ARE WELCOME
For further information, please contact Prof. P.C.Y. Chow at 3917 7905.